Chapter 01: Introductory Concepts & Definitions

1- The density of atmospheric air is about 1.15 kg/m^3, which we assume is constant. How large an absolute pressure will a pilot encounter when flying 2000 m above ground level, where the pressure is 101 kPa? Take g = 9.8 m/s^2. *Answer:* 78.46 kPa

2- At the sea level, atmospheric pressure is 1025 mbar. What pressure do you feel if you climb a hill up to 250 m in elevation, in mmHg? Assume that the density of air is 1.18 kg/m^3. *Answers:* 99.6 kPa (~747 mmHg)

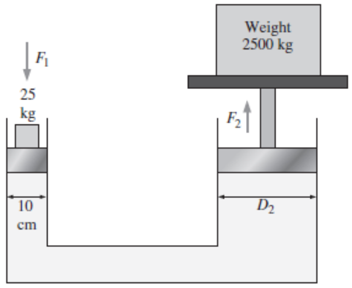
3- A vertical piston-cylinder device contains a gas at an unknown pressure. If the outside pressure is 100 kPa, determine (a) the **gage pressure** of the gas if the piston has an area of 0.2 m^2 and a mass of 20 kg. Assume g = 9.81 m/s^2. (b) ***What-if-Scenario:*** How would the answer in (a) change if the orientation of the device is changed upside down. (c) Would the answers change if the cylinder contains liquid water instead?

Answers: (a) 0.981 kPa (gage) (b) 99.02 kPa (abs) 0.981 kPa (vacuum), (c) No

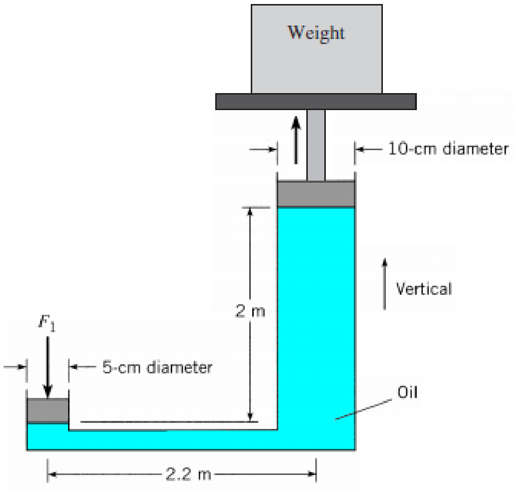
4- A vertical pressure gage connected to a vertical piston-cylinder device read 20 kPa at a location where the atmospheric pressure is 100 kPa. The piston-cylinder device with a piston area of 0.1 m^2 contains a liquid. Assuming g = 9.81 m/s^2, determine (a) the mass of the piston. (b) Would the answers change if the cylinder contains gas instead? ***What-if-Scenario:*** How would the answer in (a and b) change if the orientation of the device is changed upside down. *Answer:* (a) 203.9 kg

5-As shown in P05, a hydraulic lift is to be used to lift a 2500 kg weight by putting a weight of 25 kg on a piston with a diameter of 10 cm. Determine the diameter of the piston on which the weight is to be placed. Neglect the mass of both pistons. *Answer:* 1 m

6- As shown in P06, a hydraulic lift is to be used to lift a body of unknown weight by applying a force of F_1 = 100 N on the small piston with a diameter of 5 cm. Determine the magnitude of the weight placed on the large the piston. Assume the density of oil is 850 kg/m^3. *Answer:* 269 N



P05



P06

Exercise

Suppose that you set up three barometers *A*, *B* & *C* at the same location where the atmospheric pressure is 96 kPa. The densities of the fluids used are ρ_A = 880 kg/m^3, ρ_B = 1,000 kg/m^3 and ρ_C = 1.250 kg/m^3. Which of the barometers would have a higher column of liquid? Explain your answer. Rank from greatest to least.

Chapter 02: Energy & 1st Law of Thermodynamics

1- As shown in Fig P01, a compressed spring above the piston exerts a force of 60 N on the piston. Determine the **gage pressure** inside the cylinder

2- Warm air is contained in a piston-cylinder assembly oriented horizontally, as shown in Fig P02. The air cools slowly from an initial volume of 0.003 m^3 to a final volume of 0.002 m^3. During the process, the spring exerts a force that varies linearly from an initial value of 900 N to a final value of zero. The atmospheric pressure is 100 kPa, and the area of the piston face is 0.018 m^2. Friction between the piston and the cylinder wall can be neglected. Sketch a P-V diagram. For the air in the piston-cylinder assembly,

1. Determine the initial and final pressures, each in kPa and atm.
2. Would the answers change if the cylinder contains liquid water instead?
3. Determine the work done on the air during the process.
4. List all extensive and intensive properties mentioned in the problem.

Answers: (1) P_{init} =150 kPa (*abs*) = 1.48 *atm*, P_{final} = 100 kPa (*abs*) = 0.99 *atm*

3- A 5-kg piston in a cylinder with diameter of 100 mm is loaded with a linear spring and the outside atmospheric pressure is 100 kPa, as shown in Fig P03. The spring exerts no force on the piston when it is at the bottom of the cylinder, and for the state shown, the pressure is 400 kPa with volume 0.4 L. The valve is opened to let some air in, causing the piston to rise 2 cm. Sketch a P-V diagram.

1. Find the new pressure.
2. Would the answer in (1) change if the cylinder contains liquid water instead?
3. Determine the work done during the process.
4. List all extensive and intensive properties mentioned in the problem.

Answers: (1) P_2 = 515.3 kPa (*abs*)

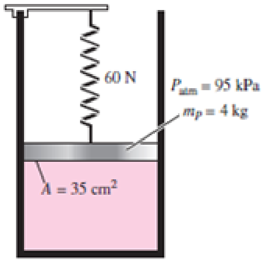


Fig. P01

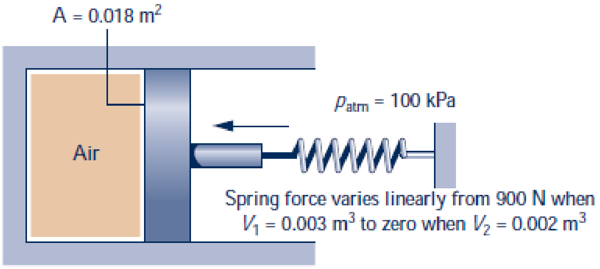

A = 0.018 m^2
Air
p_{atm} = 100 kPa
Spring force varies linearly from 900 N when
V_1 = 0.003 m^3 to zero when V_2 = 0.002 m^3

Fig. P02

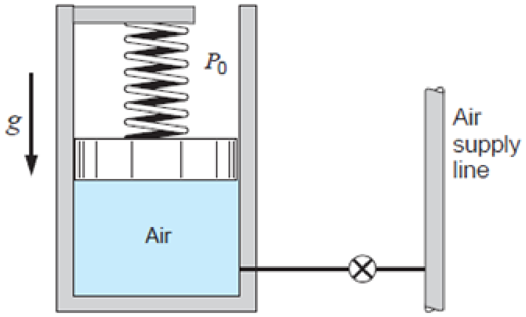


Fig. P03

Chapter 02: Energy & 1st Law of Thermodynamics

1- كما موضح في الشكل P01، يبذل النابض المضغوط قوة مقدارها 60 N على المكبس. احسب مقدار الضغط المقاس داخل الاسطوانة.

2- هواء دافئ محصور داخل تركيبة اسطوانة ومكبس في وضع أفقي كما موضح في الشكل P02. برد الهواء ببطء فتقلص الحجم من 0.003 m^3 إلى حجم نهائي 0.002 m^3. خلال العملية يبذل النابض قوة تتغير خطيا من قيمة ابتدائية مقدارها 900 N إلى نهائية مقدارها صفر. الضغط الجوي مقداره 100 kPa ومساحة مقطع المكبس تساوي 0.018 m^2. الاحتكاك بين المكبس وجدار الاسطوانة يمكن إهماله. ارسم مخطط P-$\not{V}$.

1. احسب الضغط الابتدائي والنهائي بوحدة kPa & atm.
2. هل ستتغير إجابتك إذا كانت الاسطوانة تحتوي على ماء في الطور السائل بدلا من الهواء؟
3. احسب الشغل المبذول على الهواء خلال العملية.
4. عدد وصنف كل الخواص (extensive & intensive) المنصوص عليها في السؤال.

Answers: (1) P_{init} =150 kPa (*abs*) = 1.48 *atm*, P_{final} = 100 kPa (*abs*) = 0.99 *atm* (2) – 125 J

3- حُمّلت منظومة اسطوانة ومكبس بنابض خطي كما هو موضح بالشكل P03 بحيث كانت كتلة المكبس 5 kg وقطره 100 mm والضغط الجوي يساوي 0.1 MPa. إذا علمت أن النابض لا يبذل أي قوة على المكبس عندما يكون المكبس في قاع الاسطوانة، وللحالة المبينة في الشكل كان الضغط داخل الاسطوانة 400 kPa عندما كان الحجم 0.4 L ، إثرها ارتفع المكبس مسافة 2 cm نتيجة لفتح الصمام والسماح لدخول بعض الهواء إلى الاسطوانة. ارسم مخطط P-$\not{V}$.

1. احسب الضغط النهائي.
2. احسب مقدار ثابت النابض بوحدة kN/m.
3. احسب الشغل المبذول خلال العملية.
4. إذا كان ما يُعرف بوضع الراحة (rest position) للنابض الخطي هو الوضع المبين في الشكل P03 فكم سيكون الضغط النهائي لحظة ارتفاع المكبس مسافة 2 cm؟ ملاحظة: استخدم نفس بيانات السؤال.

Answers: (1) P_2 = 515.3 kPa (*abs*)

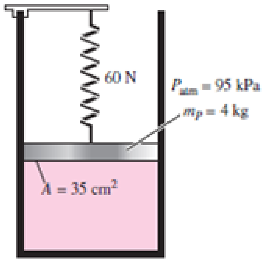


Fig. P01

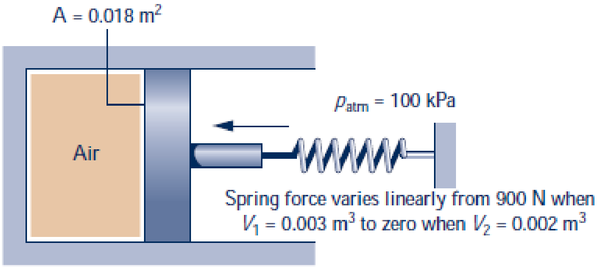

A = 0.018 m^2
Air
p_{atm} = 100 kPa
Spring force varies linearly from 900 N when
V_1 = 0.003 m^3 to zero when V_2 = 0.002 m^3

Fig. P02

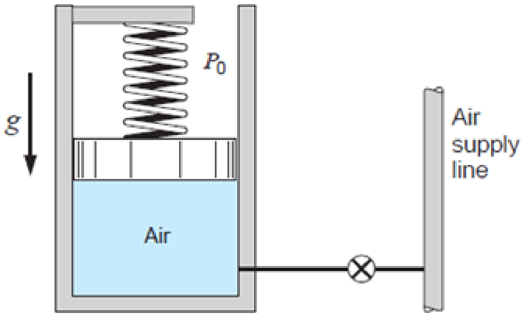


Fig. P03